Sandia BOS Testing

BRIEF

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Standardized PV Battery Test

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Background

Generally batteries are not specifically designed for use in PV systems. Most PV system batteries are designed for use in deep-cycle electric vehicle or recreational vehicle applications where the recharge is complete. PV system battery-charging issues such as water loss, electrolyte stratification, limited recharge time, and long periods at a low state-of-charge are typically not considered by battery manufacturers when presenting recommendations for charging their batteries. Sandia is developing a test procedure that will help bridge the technical and informational gap between battery manufacturers, charge controller manufacturers, and PV system integrators. The results of this ongoing work will be incorporated in an international standard.

Unit Tested

The flooded lead-calcium Delco 2010 battery (rated at 100 Ah with > 282 cycles for 60% DOD) is used to demonstrate the evaluation technique. It cannot be watered.

Objective

The objective of this work is the identification of constant voltage (CV) and on/off PV charge controller voltage regulation (Vr) set-points that will result in a high battery state-of-charge without excessive water loss. A charging scheme for the Delco 2010 battery is considered acceptable **if** the projected lifetime water loss is less than the battery reserve (2820 ml), and **if** the electrolyte is adequately mixed (demonstrated by high battery capacity after the shallow cycles).

Test Procedure

A PV battery test procedure has been defined and evaluated that simulates PV shallow-cycle and charge conditions. The test procedure is a controlled process that first establishes battery capacity after an equalization charge, then applies 20 shallow cycles using a specific charge control algorithm and set-point, and concludes with a final battery capacity test. It has been empirically established that the battery cycle performance stabilizes after 20 cycles. This procedure simulates PV charging conditions by constraining 1) the available charge-Ah to load-Ah ratio to 1.25:1, 2) the charge/discharge rate to battery capacity/33 (3.0 amps), 3) the discharge time to four hours, and 4) the recharge time to 5 hours. After 20 cycles the battery is discharged to 10.5 Vdc. The battery capacity is defined as the amp-hours that are extracted from the battery on this discharge (see Chart1). After the discharge, the battery is again charged, and the shallow cycles are repeated, if desired. The percentage of overcharge quantifies the additional Ah charged in excess of the Ah discharged.

Test Results

The procedure was conducted using, one on/off set-point **(Case 1)**, and two different constant voltage set-points (**Cases 2 and 3)**. The results of these three cases are summarized in the table below. The discharges and charges are conducted at 3 amps. Chart 1 shows the voltage and amp-hour curves for Case 1; the results indicate that after 20 shallow cycles, the battery capacity dropped from 99.5 to 94.2 Ah (6% drop). Chart 2 shows the percentage of overcharge for all three cases.

	algorithm type	Vr	Vrr	capacity decrease	avg daily H_2O loss	final overcharge
Case 1	on/off	16.2 (disconnect)	13.7 (reconnect)	6%	1.54 g	3%
Case 2	constant V	15.8	N/A	0%	2.3 g	9%
Case 3	constant V	15.5	N/A	3%	1.8 g	5%

Chart 1: Delco 2010 On/Off Charge Control Cycling

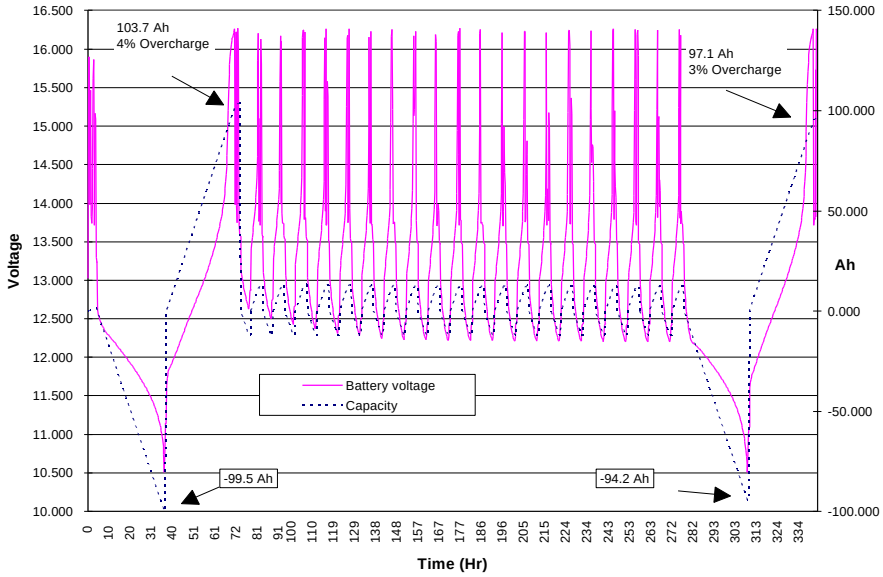
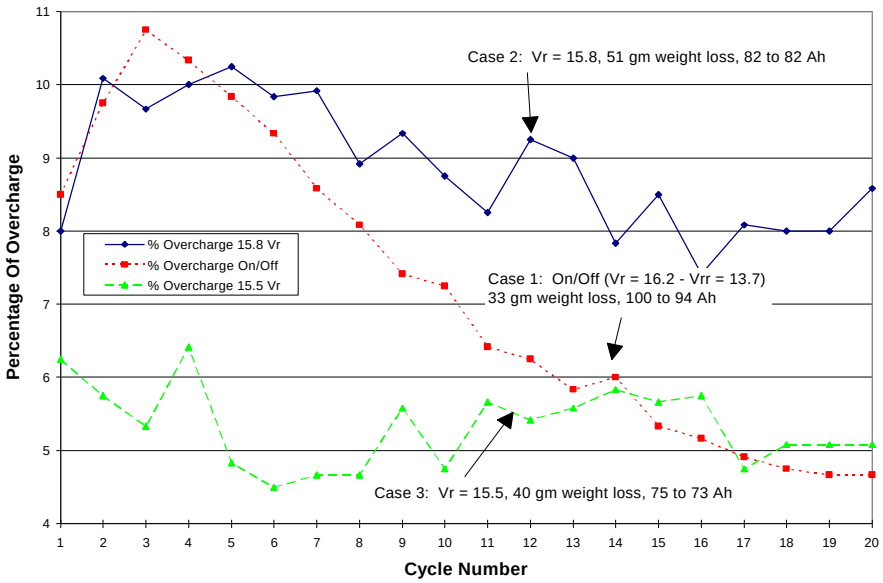


Chart 2: Delco 2010 Summary Performance Data



Discussion

Using the above test, calculations were performed that indicate water loss would not cause the Delco 2010 battery to fail prematurely for any of the three cases. These calculations were based on the battery's reserve electrolyte volume, water consumption per cycle, and expected cycle-life. Battery performance measurements are now being conducted to confirm the test results in an actual PV system. The above charge control voltage set-points are only for the Delco 2010 battery using the above charging parameters. These set-points would far exceed those used for flooded lead-antimony deep-cycle batteries. Future tests on other batteries will include three constant voltage and three on/off set-points.

Significance

The above battery test procedure has made it possible to conduct controlled and reproducible battery performance tests in much less time then previously possible. These tests aid in defining appropriate charging set-points and in predicting battery maintenance intervals for specific charge conditions encountered by PV systems.

For More Information:

Tom Hund, (505) 844-8627 or Steve Harrington, (505) 844-3779
Sandia National Laboratories, Albuquerque, NM, 87185-0753